

Disinflation and the Phillips Curve: Israel 1986-2015

Rafi Melnick*
Till Strohsal*²



* IDC Herzliya, Israel

*² Freie Universität Berlin, Germany

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Rafi Melnick^a and Till Strohsal^{b*}

^a The Interdisciplinary Center, IDC Herzliya and ^b Freie Universität Berlin

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Abstract

A Phillips Curve (PC) framework is utilized to study the challenging post-1985 disinflation process in Israel. The estimated PC is stable and has forecasting power. Based on endogenous structural break tests we find that actual and expected inflation are co-breaking. We argue that the step-like development of inflation is in line with shocks and monetary policy that changed inflationary expectations. The disinflation process was long, and a long-term commitment by both the Central Bank and the government was required. Credibility was achieved gradually and the transition from the last step of 10% to 2% inflation was accomplished by introducing an inflation targeting regime.

Keywords: Phillips Curve, Expected Inflation, Opportunistic Disinflation, Multiple Breakpoint Tests, Inflation Targeting

JEL classification: E31, E52, E58, C22

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E-mail: ^a melnick@idc.ac.il; ^b till.strohsal@fu-berlin.de

1. Introduction

The forward-looking Phillips Curve (henceforth PC) is one of the most important components of New-Keynesian macroeconomic theory. The seminal contributions of Friedman (1968) and Phelps (1967) added expected inflation to the Phillips curve version of Samuelson and Solow (1960). The theoretical developments that followed provided a micro foundation for the forward-looking PC (see e.g., Clarida et al., 1999 and Woodford, 2003). Today, the PC is considered a principal economic relationship in monetary policy practice.¹

In the academic literature there has been an ongoing debate about the empirical validity of the PC (see e.g., Gali et al., 1999, Lindé, 2005, Rudd and Whelan, 2005, and Gali et al., 2005). More recently, the *stability* and *forecasting* performance of the Phillips curve are at the center of the discussion. For instance, Ball and Mazumder (2011) argue that there is a conundrum because post-crisis U.S. inflation did not fall as much as predicted by a PC estimated over 1960-2007. Stock (2011) finds, however, that accounting for moderate time variation in the PC equation can resolve this puzzle. Gordon (2013) challenges the view of some skeptical economists that “*The Phillips Curve is widely viewed as dead, destined to the mortuary scrapyard of discarded economic ideas*”, showing that the PC properly explains the U.S. inflation rate and thus “*is alive and well*”. When Ball and Mazumder (2014) assume perfectly anchored inflation expectations, they are able to produce a stable PC relationship for the U.S., resolving the puzzle. Mavroeidis et al. (2014) discuss numerous econometric issues related to the identification and the estimation of the PC. A major conclusion of their survey is that “*new datasets are needed to reach an empirical consensus*”.

This paper studies the disinflation process of Israel and provides new evidence for a stable and reasonably well forecasting forward-looking PC. The estimation is based on financial market data for inflation expectations and different measures of

¹ See Gordon (2011) for a survey of the Phillips curve’s history, which certainly has been controversial. The PC became a principal economic relationship in monetary policy practice in the US in the 1970s.

real economic activity focusing on the period of disinflation after the 1985 stabilization program.² Our empirical strategy, adjusted to the case of Israel, involves two stages. First, we estimate a PC by least squares and instrumental variables, showing that the relation is stable. We find that over a set of alternative specifications the coefficient for inflation expectations always has the right sign, is highly significant and takes on a value very close to unity. This is in line with economic theory. Similarly, the coefficient of real economic activity always has the right sign, and is significant in the majority of cases. The estimated PC proves useful for forecasting inflation. We do not encounter a puzzle of a missing fall or rise in inflation. Second, we use a number of endogenous structural break tests (see Perron, 2006) in a univariate analysis of inflation and inflation expectations to show that the series are actually co-breaking. The inflation steps discussed in Liviatan and Melnick (1999) are also found in expected inflation. The timing of the breaks and the formation of the steps, from the 1985 stabilization on, are related to the conduct of monetary policy, distinct exogenous shocks and the introduction of inflation targeting.

Our paper is structured as follows. Section 2 discusses preliminary econometric issues. In Section 3 we estimate the PC in Israel for the period of 1986-2013. We test for the stability of the estimated function and evaluate its forecasting performance out of the estimation sample in 2014-2015. The dynamics of expected and actual inflation are explored in Section 4, where we perform multiple break point tests separately to actual and expected inflation. In Section 5 we connect the econometric results with Israeli economic developments and policy. Conclusions and policy implications are discussed in Section 6.

² During the year that preceded the stabilization program the rate of inflation was above 400%. The stabilization program is briefly described in Appendix 2. See also Bruno (1993), Bruno and Piterman (1988) and Liviatan and Melnick (1999).

2. Preliminary Econometric Issues

Mavroeidis et al. (2014) derive the PC from micro foundation principles. This exercise leads to the basic equation:³

$$\pi_t = \beta E_t(\pi_{t+1}) + \gamma y_t + \varepsilon_t. \quad (1)$$

π_t is the rate of inflation in period t , $E_t(\pi_{t+1})$ is expected future inflation, y_t is a real variable proportional to the output gap in period t , β and γ are parameters and ε_t is a stochastic shock. Equation (1) represents the relation to be estimated in the next section.

Mavroeidis et al. (2014) discuss the challenge of dealing with unobserved expected inflation $E_t(\pi_{t+1})$. They consider three options; replacing expectations by realizations, deriving expectations from a VAR model, or using surveys of expectations. All options require the use of instruments to tackle the simultaneity. An additional contribution of our study is the use of a fourth alternative to deal with unobserved expected inflation. We propose to use inflationary expectations derived from financial markets. It is known from the literature that those estimates may not be a pure measure of expectations due to a risk premium and liquidity issues, (see e.g., Pflueger and Viceira, 2011). Melnick (2016) estimates an inflation risk bias of 21 basis points for Israel. In the empirical specification of equation (1), we include a constant term which should pick up this risk bias. The possible endogeneity of expected inflation is econometrically dealt by instrumental variable estimation, using lagged actual inflation as instruments.

Milton Friedman commented, in a letter he sent to Michael Bruno⁴ after the 1985 stabilization program, on the use of the difference between two bonds issued by the government; one, nominal, and the other a purchasing power bond fully adjusted

³ Equation (8) in their paper.

⁴ Governor of the Bank of Israel after the 1985 stabilization program.

to inflation⁵ "... that difference could serve as an alternative nominal anchor to the system. As for myself, for the U.S. it is the first nominal anchor that has been suggested that seems to me to have advantages over the nominal money supply."⁶ Being a strong believer of the efficiency of competitive markets, it seems that Friedman supported the use of market derived expected inflation as superior to other methods of evaluating expected inflation.

To account for possible endogeneity of the output gap y_t , we use two alternative measures of y_t : lagged unemployment and lagged deviation of the log of GDP from an HP filter.

3. Empirical Assessment of the Israeli Phillips Curve

3.1 Data on Inflation and Inflation Expectations

Figure 1 displays actual and expected inflation⁷ from 1986Q1 to 2013Q4. The rate of inflation is the quarter-on-quarter percentage change in CPI, expressed in annual rates. Expected inflation has an expectations horizon of one year and is measured by the difference in returns to unindexed government bonds and fully CPI-indexed bonds. Clearly, the rate of inflation fluctuates around a less volatile rate of expected inflation. By casual observation, it seems that expected and actual inflation evolve in steps until the mid-1990s. Figure 1 also suggests that there is a transition period between 1996 and 2001 when both time series begin a gradual decline finally reaching a long period of relative price stability.⁸

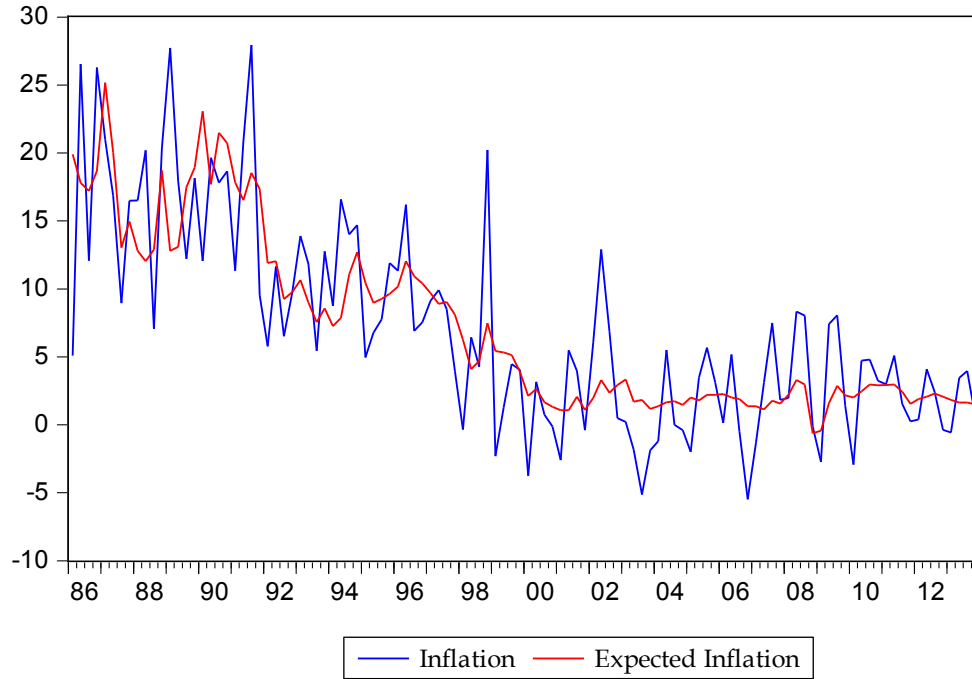
⁵ Yariv (1986) developed some proxies on that line and they were used after the stabilization of 1985.

⁶ This was written before the TIPS were issued in the U.S.

⁷ For a detailed description of the data see Appendix 1.

⁸ 2% is the center of the inflation target range in Israel, which was introduced in 2003.

Figure 1. Actual and Expected Inflation
1986Q1 - 2013Q4
 (percent change at annual rates)



3.2 Estimated Phillips Curve

Table 1 presents eight versions of the estimated PC. Four of them are estimated by OLS and four by TSLS using lagged inflation as an instrument for expected inflation. In equations 1-4, we use the fourth lag of the deviation of log GDP from an HP filtered trend, YGAP. In equations 5-8, we use lagged unemployment, U, as a measure of the output gap. All equations include a seasonal dummy for the second quarter. Equations 3, 4, 7 and 8 include dummies for outliers at the last quarter of 1998 and the second quarter of 2002, which experienced large price changes due to

exceptionally large exchange rate shocks.⁹ Standard errors are estimated with the HAC Newey-West correction for heteroskedasticity and autocorrelation.

Table 1. Phillips Curve Estimation*

1986Q1 – 2013Q4

(p values in parenthesis)

	(1)	(2) ¹	(3) ²	(4) ^{1,2}	(5)	(6) ¹	(7) ²	(8) ^{1,2}
	OLS	TSL	OLS	TSL	OLS	TSL	OLS	TSL
C	-0.72 (0.13)	-0.95 (0.10)	-0.92 (0.06)	-1.20 (0.02)	1.80 (0.25)	1.58 (0.33)	2.26 (0.14)	2.01 (0.18)
π_t^e ³	0.96 (0.00)	1.00 (0.00)	0.97 (0.00)	1.01 (0.00)	0.97 (0.00)	0.99 (0.00)	0.97 (0.00)	0.99 (0.00)
U(-1)					-0.29 (0.14)	-0.28 (0.15)	-0.36 (0.04)	-0.35 (0.05)
YGAP(-4)	0.55 (0.00)	0.56 (0.00)	0.55 (0.01)	0.56 (0.00)				
R ²	0.71	0.71	0.75	0.75	0.71	0.71	0.75	0.75
DW	1.71	1.70	1.60	1.59	0.72	1.72	1.69	1.69

* We estimated the equation $\pi_t = c + \beta E_t(\pi_{t+1}) + \gamma y_t + \varepsilon_t$. P-values in parentheses are based on HAC standard errors with Newey-West correction for heteroskedasticity and autocorrelation. All equations include a seasonal dummy for the second quarter.

¹ Lagged inflation is the instrument for expected inflation.

² Including dummies for 98.4 and 2002.2 quarters of large exchange rate shock on prices.

³ π_t^e is the one year horizon breakeven inflation.

In all equations we cannot reject the null hypothesis that β (the coefficient of expected inflation) is equal to 0.99. Given quarterly data, 0.99 is the standard value assigned to this parameter in theoretical models (see e.g., Clarida et al., 2000). The

⁹ Cukierman and Melnick (2015) showed that the pass-through from the exchange rate to prices is virtually 1 for that period.

β estimated by TSLS is always larger than the one estimated by OLS, indicating a correction of the simultaneity bias. The impact of the output gap, as measured by the deviation of log GDP from the HP filter, is highly significant and stable across the different specifications. When using the rate of unemployment as a proxy for real activity, we obtain the economically plausible negative sign. However, unemployment is found to be significantly different from zero only in the equations that include the price shocks dummies¹⁰.

3.3 Stability of the Phillips Curve

We apply a number of tests to investigate the stability of the estimated PC. The tests refer to our baseline specification with OLS estimation and the output gap. Beginning with an intuitive procedure, Figure 2 shows recursively estimated residuals. Notice that the estimated residuals lie well within the band of two standard errors and do not exhibit outliers, perhaps caused by parameter changes.

¹⁰ We estimated the PC for the period 2001Q2-20013Q4 to check whether the PC has become flatter, for the Israeli case this was rejected.

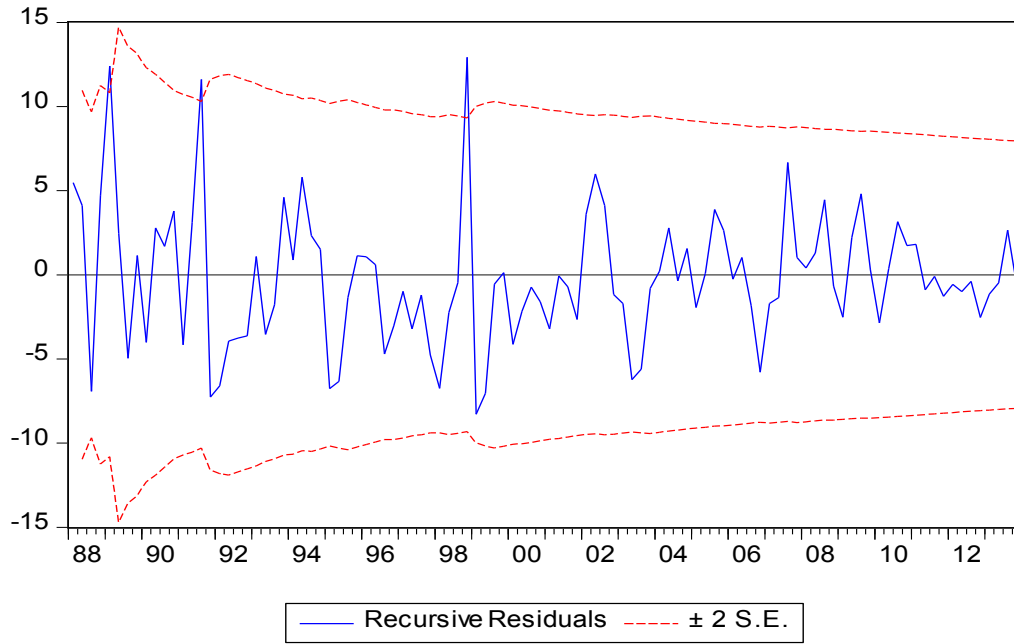
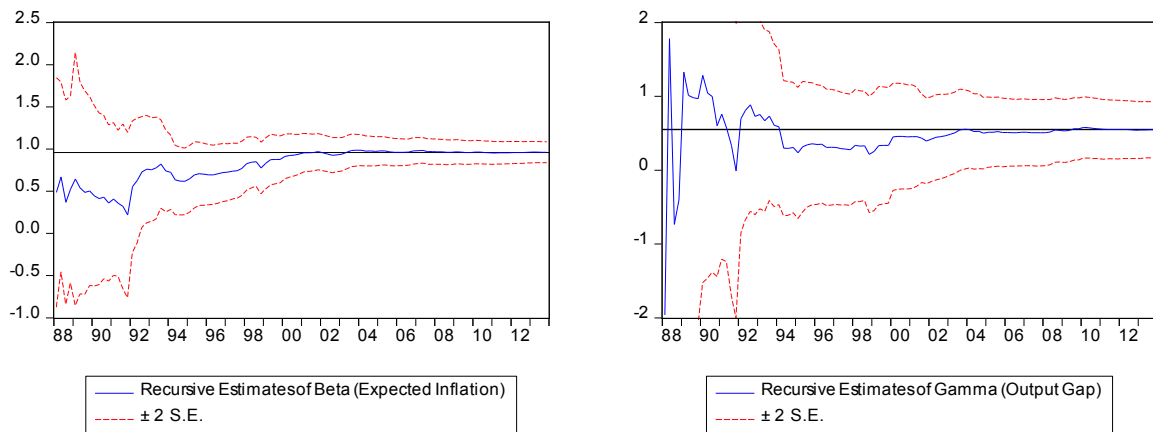
Figure 2: Recursively Estimated Residuals

Figure 3 shows that the recursively estimated slope parameters for both expected inflation and the output gap stabilize fairly quickly around the values obtained from the estimation over the full sample (black horizontal lines).¹¹

Figure 3: Recursively Estimated Parameters

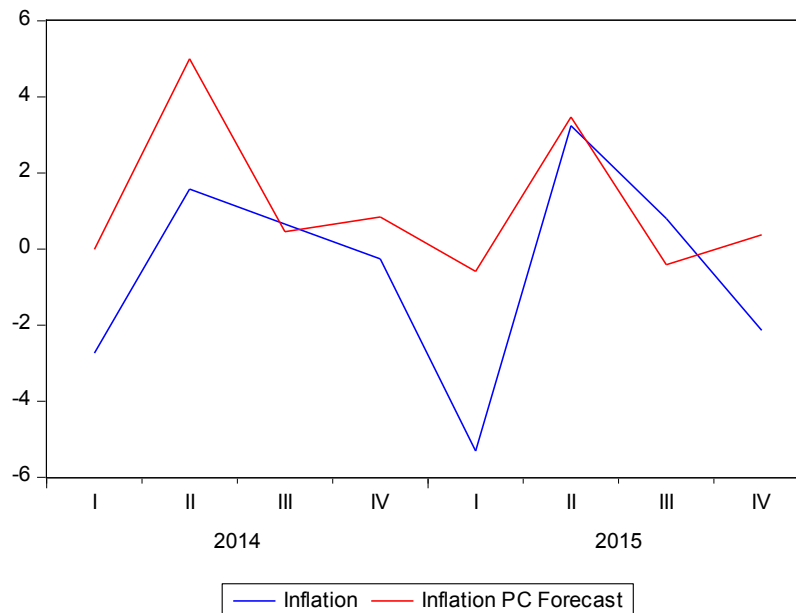
¹¹ The stability also applies to the constant term.

Formal break point tests confirm these results. Neither the Qandt-Andrews test for a single endogenous break nor the multiple break point test of Bai and Perron (1998) finds evidence for unstable parameters. The test statistics for those tests are 2.13 [QA] and 2.13, 2.38 [BP], respectively, and are all far below the critical values for rejection of stability.

3.3 Forecasting Ability

We also evaluate the PC's ability to forecast inflation out of the estimation sample from 2014Q1 to 2015Q4. The forecast is performed using equation 1 in Table 1 and is displayed in Figure 4. Except for the strong negative decline in the CPI in the first quarter of 2015, mainly due to the sharp decline in oil prices, the forecast seems to do a reasonable job, notwithstanding the difficulty in forecasting inflation. The root-mean-square error (RMSE) of the PC forecast is 1.89, while that of an autoregressive forecast, which might be considered a natural benchmark, is 2.34. In any case, the rate of actual inflation lies within the 2 standard errors band of the PC forecast, including the first quarter of 2015. We do not find a “missing inflation” phenomena as encountered for the U.S. in Ball and Mazumder (2011).

**Figure 4. Inflation and Inflation Phillips Curve Forecast
2014.1 - 2015.4**



From Figure 1 and the estimated PC equations, which document basically a one-to-one relation of expected and actual inflation, we conclude that the expected disinflation in the post-stabilization era of Israel is in line with the actual disinflation.

4. Expected and Actual Inflation after Israel's 1985 Stabilization Program

In this section we characterize the time series properties of expected and actual inflation in the post-stabilization era. According to the forward-looking PC, inflation dynamics are driven by inflation expectations. And, according to the disinflation-in-steps hypothesis of Melnick and Liviatan (1999), the stabilization program was followed by a stepwise declining inflation rate. The PC relation hence implies that expected inflation must have developed in steps too, causing a similar stepwise decline of actual inflation.

We therefore test the disinflation-in-steps hypothesis by testing for multiple endogenous structural breaks in the following, purely statistical, model

$$p_t = c_i + \varepsilon_t, \quad i = 1, \dots, l + 1. \quad (2)$$

The tests we use were developed in Bai (1997), Bai and Perron (1998), Bai and Perron (2003a) and Bai and Perron (2003b) (see Appendix 3 for further details). In equation (2), p_t may stand for expected inflation π_t^e or actual inflation π_t . We use quarterly observations from 1986Q1 through 2013Q4. The error term ε_t may be autocorrelated and heteroskedastic. The level parameter c_i is allowed to break up to l times which gives us $l + 1$ steps.

The break tests reveal several interesting results. First, both expected and actual inflation break two times. Second, the series are virtually co-breaking. The breaks in inflation expectations occur at 1992Q1 and 1998Q2, while for actual inflation the

tests find breaks at 1991Q4 and 1999Q1.¹²

A properly defined step should be a constant average inflation without a trend. However, as mentioned earlier, data in Figure 1 suggest that there may have been a more gradual transition from one step to the next, particularly in the late 1990s. To further explore the nature of the breaks, we perform tests in a more general model that allows for potentially different time trends in each sub-period.

$$p_t = c_i + \delta_i * T + \varepsilon_t, \quad i = 1, \dots, l + 1. \quad (3)$$

In equation (3), T is a deterministic time trend that may have a different slope parameter δ_i in each regime.

The multiple break tests yield the following estimated equation (3) for expected inflation.¹³

Regime 1, 1986Q1 - 1991Q4	$\pi_t^e = 17.1 \hat{\varepsilon}_t$ (9.9)
Regime 2, 1992Q1 - 1995Q4	$\pi_t^e = 11.8 + \hat{\varepsilon}_t$ (4.6)
Regime 3, 1996Q1 - 2001Q2	$\pi_t^e = 32.9 - 0.5 * T + \hat{\varepsilon}_t$ (25.6) (-22.7)
Regime 4, 2001Q3 - 2103Q4	$\pi_t^e = 2.0 + \hat{\varepsilon}_t$ (2.6)

The R^2 of this regression is 0.92 and t-statistics are given in parentheses.

In the more general model, the breaks test reveal an additional regime. We now have 3 disinflation steps including a gradual transition period. The first step formed after the 1985 stabilization program from 1986Q1 to 1991Q4. The second step formed after the large immigration wave to Israel from the former Soviet Union from 1992Q1 to 1995Q4. There is a transition period with a trend decline in the rate of inflation starting with the implementation of an inflation targeting monetary policy from 1996Q1 - 2001Q2. The third step is the current price stability

¹² See Table A3.1 in appendix 3.

¹³ We omit statistically insignificant sub-period trends. In regimes 1, 2 and 4 the constant can be interpreted as the average expected inflation.

step beginning in 2001Q3 and continuing through 2013Q4. In the next section we relate our econometric results with Israeli economic developments and policy.

5. Expected and Actual Inflation Steps and Transition to Price Stability

5.1 The Formation of the First Step 1986Q1 - 1991Q4

Israel's stabilization program of 1985 was clearly successful in achieving its main objective of strongly reducing inflation. While the inflation rate from January to July 1985 was close to 400%, by 1986 it was already less than 20%. However, while a deterioration to full-fledged hyperinflation was prevented, the program did not fully eliminate high inflation levels when judged by Western standards. The stabilization program corrected the fundamental fiscal and balance of payments imbalances, and provided the Central Bank a basic law to carry out independent monetary policy. Nevertheless, expected inflation remained stuck at about 20% for an extended period from 1986Q1 until 1991Q4.¹⁴ What is a plausible explanation of this phenomenon?

To begin with, the stabilization program had to deal with the crucial absence of credibility. The non-orthodox components of the program were similar to measures taken before the program's initiation, when a series of "package deals"¹⁵ failed to solve the problem. To further complicate matters, the fundamental correction of the fiscal and balance of payments deficits was not well understood and was received with skepticism.¹⁶

¹⁴ A large portion of inflation vanished, as described in Sargent (1982) but a hard core residual 20% inflation remained.

¹⁵ The package deals were tripartite price-wage agreements between the government, the Histadrut (The National Trade Union), and the employers' organization. These deals were signed typically after a price shock due to subsidy cuts and a devaluation of the currency to deal with the fiscal deficit and the balance of payments crises.

¹⁶ Support for this view is the critical approach to the stabilization program of leading professors of economics at Tel Aviv University.

However, despite beginning with difficult credibility conditions, the program succeeded in reducing inflation from levels of several hundred percent to about 20% in 1986. The large decrease of inflation was achieved at relatively low costs in terms of output loss and unemployment, so there was enormous political gain. The initial success of the program was met with an increase in acceptance and improved credibility.

After the program's initiation, the dominant policy goal was to stabilize expected inflation and thus inflation, and prevent its acceleration or a return to pre-stabilization dynamics. There were three main policy challenges. The first challenge was to avoid a rise in real wages. The nominal wage compensation agreement that was part of the program that became operational at the beginning of 1986,¹⁷ was larger than what was necessary to restore the pre-stabilization real wage level. This fact is an indication that inflation declined more than expected. A rise in real wages was avoided by further agreements with the Histadrut and the employers' organization.

The second challenge was a declining real exchange rate (in a fixed exchange rate regime) caused by a continuing inflationary trend. This was initially dealt with by incremental devaluations followed by the establishment of an exchange rate band that allowed for a trend rise in the nominal exchange rate (see Figure 5). It is clear that fixing the nominal exchange rate was not strong enough to anchor the price level¹⁸ or to fully eliminate inflation. Figure 5 shows that a devaluation was implemented in the first quarter of 1987, thus signaling that the government and the Bank of Israel were accommodating the residual inflation of 1986 in an attempt to guide inflationary expectations to the 20% initial step. This signal was further

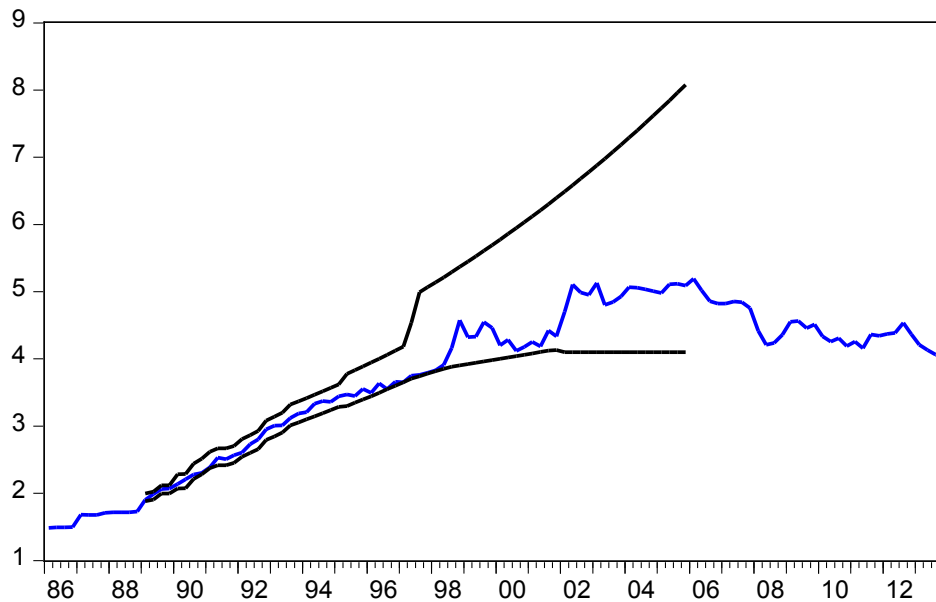
¹⁷ This compensation was arranged as part of the stabilization program to compensate workers for their agreement to give up the initial cost of living allowance, because of the price shock of the first month of the program.

¹⁸ In particular for the prices of non-tradable goods.

strengthened by introducing a moving horizontal exchange rate band and then developing a diagonal exchange rate band.

The third challenge was related to the elimination of price controls. The solution was to implement a gradual elimination of controls, allowing prices to rise at the inflation step level without re-introducing subsidization but accommodating the expected inflation step. All this helped to establish the first expected and actual inflation step of 20%. After stabilizing the 20% inflation step, the fiscal and balance of payments situation became more widely known and better understood, so the program gained credibility validating the new level of actual and expected inflation.

**Figure 5. Exchange Rate and Exchange Rate Band
1986Q1 - 2013Q4**



It is fair to say that the government and the Central Bank did not try to further decrease inflation. Their main goal was to exploit the initial disinflationary success by stabilizing the rate of inflation at 20%. The focus was on avoiding a higher or accelerating level of inflation that might be caused by an adverse shock. As Liviatan

and Melnick (1999) proposed, *"this can be understood in view of the lack of consensus about the cost-benefits-balance of further reducing inflation from its relatively low level"*. It seems that the Central Bank adopted an asymmetric policy rule of the type presented in Orphanides and Wilcox (2002), reacting strongly to a possible upward deviation from the inflation step, while taking advantage of favorable shocks by setting accordingly the rate of interest, supporting the temporary inflation step, and subsequently the inflation target.

5.2 The Formation of the Second Step 1992Q1 - 1995Q4

The transition to the second step of 10% was not the result of a new anti-inflationary policy. Rather, it occurred as the result of a large supply shock caused by the massive wave of immigration from the former Soviet Union that started in 1990. Israel absorbed 1 million immigrants, half of them between 1990 and 1992. The break date of 1991Q4 from the statistical analysis is therefore perfectly in line with this extraordinary event.¹⁹ This transition to a lower inflation step seems like an application of the disinflation strategy described by Blinder (1994): *"Proponents of this approach hold that when inflation is moderate but still above the long-run objective, the Fed should not take deliberate anti-inflation action, but rather should wait for external circumstances such as favorable supply shocks and unforeseen recessions to deliver the desired reduction in inflation. While waiting for such circumstances to arise, the Fed should aggressively resist incipient increases in inflation."*

Despite accelerated economic growth and the creation of many new jobs, unemployment increased because the size of the labor force grew at a faster rate.

¹⁹ The conditions for disinflation in Israel were favorably affected by a decline in the rate of inflation in Israel's principal trading partners' countries.

This circumstance put downward pressure on wages (see Table 2). Although the decline in real wages supported a decline in the rate of expected inflation, the massive increase in the labor force had a more substantial impact on the flexibility of the labor market. Another significant impact on the labor market was the reluctance of the immigrants from the former Soviet Union to join the labor union in Israel. This effectively reduced the power of the mighty Histadrut, resulting in a major labor market reform.

Table 2. Transition to the Second Step¹

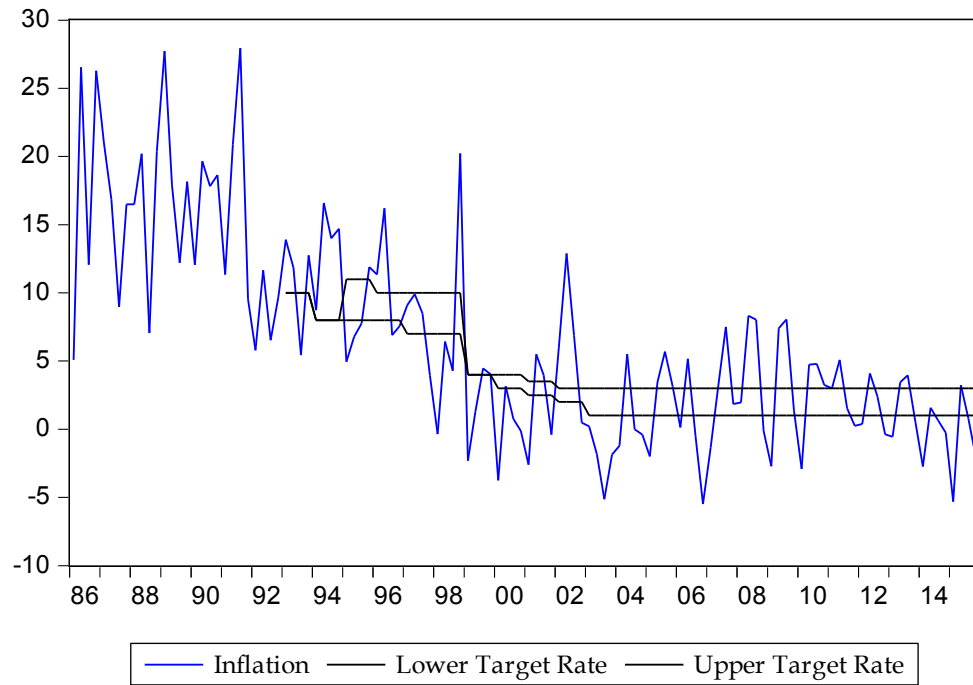
	GDP	Inflation	Unemployment	Real Wages	Immigration
1989	1.4	20.7	8.9	100	0.5
1990	6.6	17.6	9.6	99.1	4.4
1991	6.1	18.0	10.6	95.9	3.8
1992	7.2	9.4	11.2	97.1	1.6

¹ The data refer to GDP growth, Inflation as the percent change of the CPI during the year, unemployment in percent, real wage index with 1989=100 and immigration in percent of the population

During this time, monetary policy was opportunistic, as defined in Orphanides and Wilcox (2002). On the fiscal front, the passage of the balanced budget law allowed a temporary increase in the fiscal deficit needed to absorb the new immigrants without impairing government credibility. On the balance of payments front, the U.S. granted loan guarantees to finance an anticipated rise in the current account deficit associated with the absorption of the new immigrants.

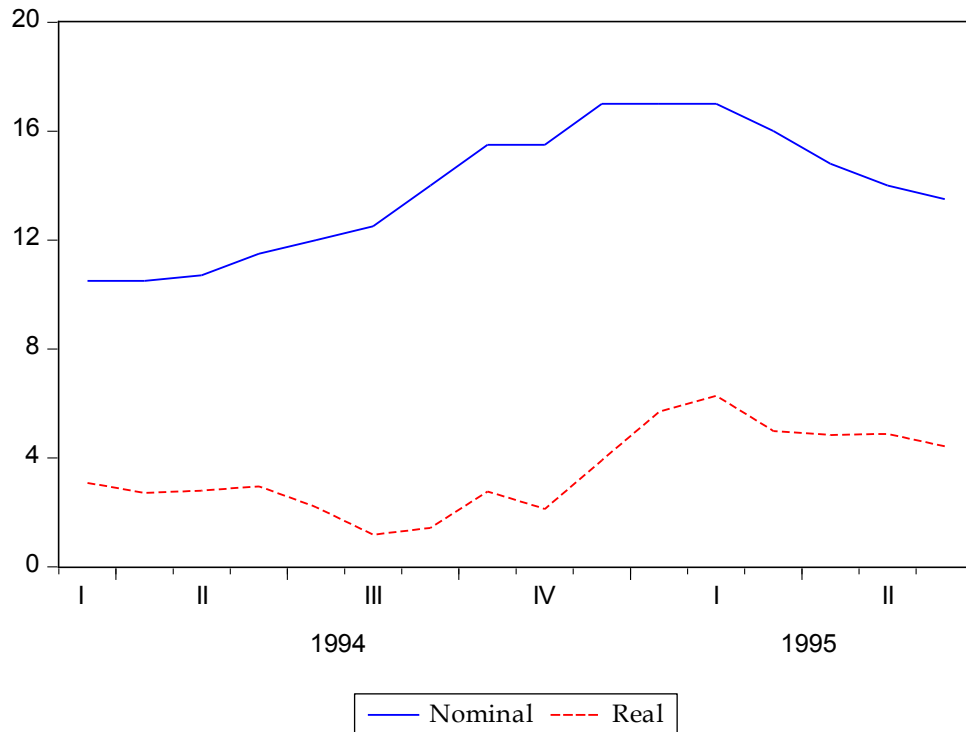
In 1993 the first inflation target was announced (see Figure 6). It was not a transition to a proper inflation targeting regime, but rather an attempt to stabilize the new lower inflation step generated by the immigration shock. Moreover, the target for the rate of inflation needed to be coordinated with the slope of the diagonal exchange rate band at a rate consistent with the difference between domestic and foreign inflation (see Ben-Bassat, 1995).

**Figure 6. Inflation and Inflation Targets
1986Q1 - 2015Q4**



The first move toward an inflation targeting regime was implemented in 1995. In Figure 7, we present the policy interest rate set by the Bank of Israel. The rise of the interest rate during 1994 was only an adjustment to the level of expected inflation, so no rise in the real expected interest rate is observed. In the first quarter of 1995, however, for the first time since the stabilization program, we see that the additional rise in the interest rate results in a rise in the real expected rate signaling that the Bank of Israel was actively applying a disinflation policy.

**Figure 7. Nominal and Real Policy Interest Rates
1994m03 - 1995m06**



This active disinflation policy led, with a few quarters lag, to a gradual decline in expected inflation.

5.2 Transition - From Second Step to Price stability 1996Q1 - 2001Q2

From 1996Q1 we estimate a decline trend in expected inflation. Although inflation targeting had an impact on inflationary expectations, conflict with the diagonal exchange rate band lessened its effectiveness (see Sokoler, 2000). In 1997, the interest rate differential between domestic and foreign rates produced large foreign exchange capital inflow. The exchange rate hit the lower limit of the exchange rate band forcing the Bank of Israel to defend the band and buy foreign exchange while sterilizing the purchases (see Figure 5). Hence, the ability of the Bank to pursue the necessary restrictive policy to reduce both expected inflation and real inflation was limited. From the 1997 episode it became clear that the exchange rate band was

incompatible with traditional disinflation monetary policy. Setting the required higher interest rates contradicted the lower exchange rate limit. In order to apply the required monetary policy necessary for further disinflation, it was essential to abandon the exchange rate band.²⁰

The transition to the step of low inflation can be attributed to the monetary policy implemented to achieve price stability under an inflation targeting regime. This was possible after eliminating the conflict between inflation targeting and the exchange rate band. First by widening the band, and then by eliminating it all together and moving to a free floating regime (see Figure 5).

Monetary policy gained credibility through two distinct episodes. Both episodes are clear illustrations of an asymmetric policy design, and change in focus towards price stability. The first episode was the Bank of Israel's reaction to the LTCM²¹ crisis of 1998 and the related Russian and South East Asian financial crises. The contagion effect of those crises had a strong impact on Israeli financial markets. The main effect was that large capital outflows produced a sharp devaluation creating a price shock because most domestic prices were indexed to the US dollar, a pathological inheritance of Israel's history of inflation (see Shiffer, 2001).

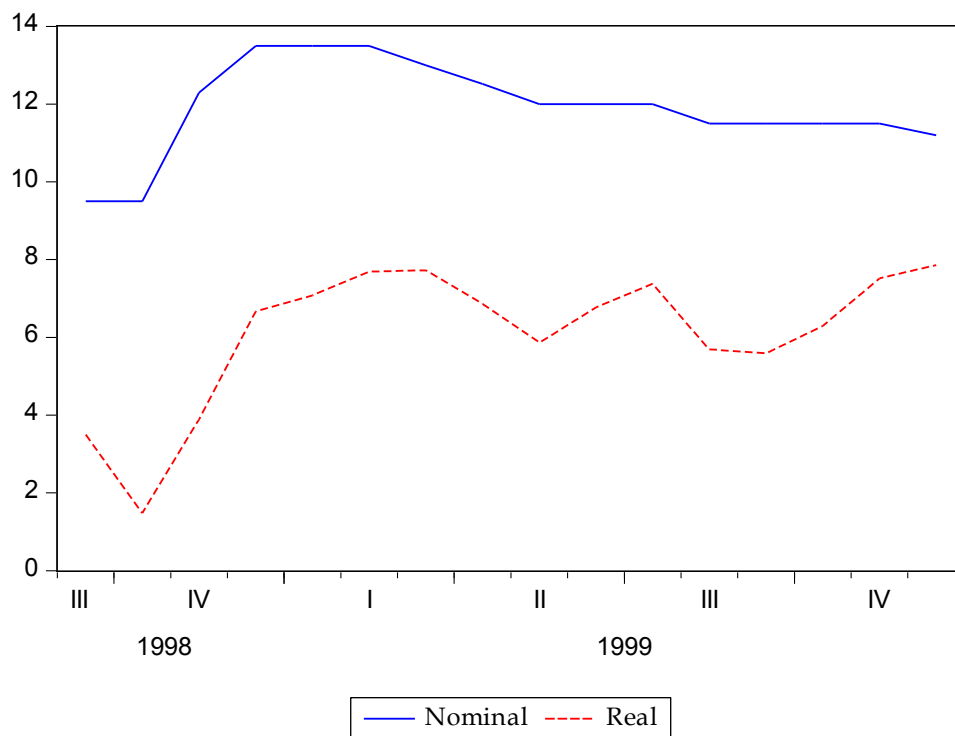
In the past, a rise in inflation was usually associated with exchange rate shocks combined with a balance of payments crisis (see Liviatan and Piterman, 1986). At that time, however, Israel was not in a balance of payments crisis. For the first time the Bank of Israel was able to deal with the price shock crisis by a sharply increasing the interest rate by 400 basis points (see Figure 8). This monetary policy shock had an immediate impact on the movement of capital. The previous outflows reversed,

²⁰ It seems that abandoning the exchange rate anchor was delayed due to lack of experience with traditional monetary policy in Israel.

²¹ Long-Term Capital Management (LTCM) was an American hedge fund management firm. The firm's most important hedge fund, Long-Term Capital Portfolio L.P., collapsed in the late 1990s.

and the exchange rate returned to pre-crisis levels. To a large extent, this resolved the impact of the previous price shock. Although the exchange rate changed its course and inflation did not accelerate, the Bank of Israel persisted with its policy of a high interest rate for a considerable time. Even though the rate of inflation was very low (in fact, the rate of inflation during 2000 was zero), the interest rate did not return to the pre-LTCM crisis level until 2000. It seems that this determined action by the Bank of Israel had a positive credibility effect on inflation expectations, convincing the public of the Bank's intentions to eliminate the residual inflation and achieve price stability.

**Figure 8. Nominal and Real Policy Interest Rates
1998m06 - 1999m12**

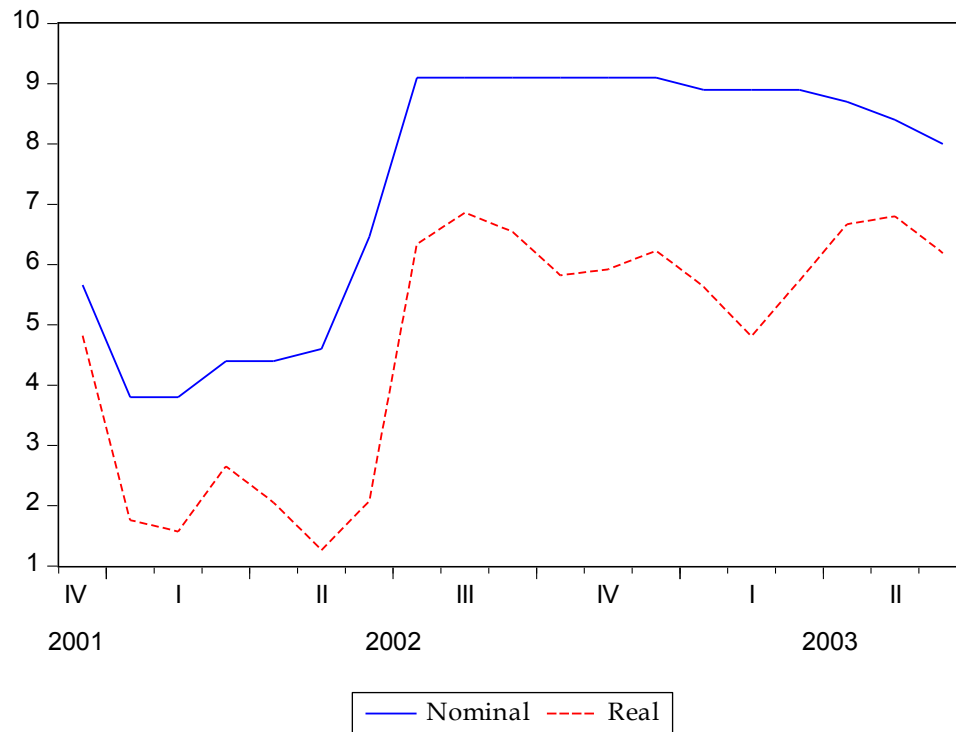


5.2 The Present Step – Price Stability 2001Q3 – 2013Q4

The beginning of Israel's efforts to preserve price stability marks the second episode that resulted in improved credibility, and allowed expected and actual inflation to settle down at the price stability inflation target.²² Although the episode was not fueled by external crises (as the LTCM), it had a similar effect on inflation expectations, reflecting the commitment of the Bank of Israel to achieve price stability. In December of 2001, in the context of a policy deal with the government, the Bank of Israel reduced its interest rate by 200 basis points to 3.8%. This was a big surprise to the markets and produced large capital outflows causing a depreciation of the currency, and a corresponding price shock similar to the shock of 1998. Again, there was concern that inflation would accelerate, wasting the previous disinflation achievements. The Bank took aggressive corrective action by raising the interest rate to 9.1%, reversing the outflow of capital and minimizing the potential exchange rate price shock (see Figure 9).

²² The price stability target was set at 1% to 3%.

**Figure 9. Nominal and Real Policy Interest Rates
2001m12 - 2003m06**



The Bank of Israel maintained the high interest rate even though the economy was suffering from a serious recession. It seems that this episode finally convinced the public of the Central Bank's commitment to maintain price stability. By 2003 expected inflation stabilized around the center of the inflation target rate at 2%. Israel finally achieved price stability bringing to a conclusion the efforts aimed at controlling inflation that began with the stabilization program of 1985.

6. Conclusion

In this study we utilize the PC framework to study the challenging post-1985 disinflation stabilization program in Israel. The sample includes the immediate disinflation experience and the prolonged transition to price stability that followed. Our econometric analysis shows that the estimated PC is stable and it has forecasting power. We use expected inflation derived from the financial market

and different measures of real economic activity. We find that, over a set of alternative specifications and estimation procedures, the coefficient for inflation expectations always has the right sign, is highly significant and takes on a value very close to unity, being in line with economic theory. Similarly, the coefficient of real economic activity always has the right sign, and is significant in the majority of cases.

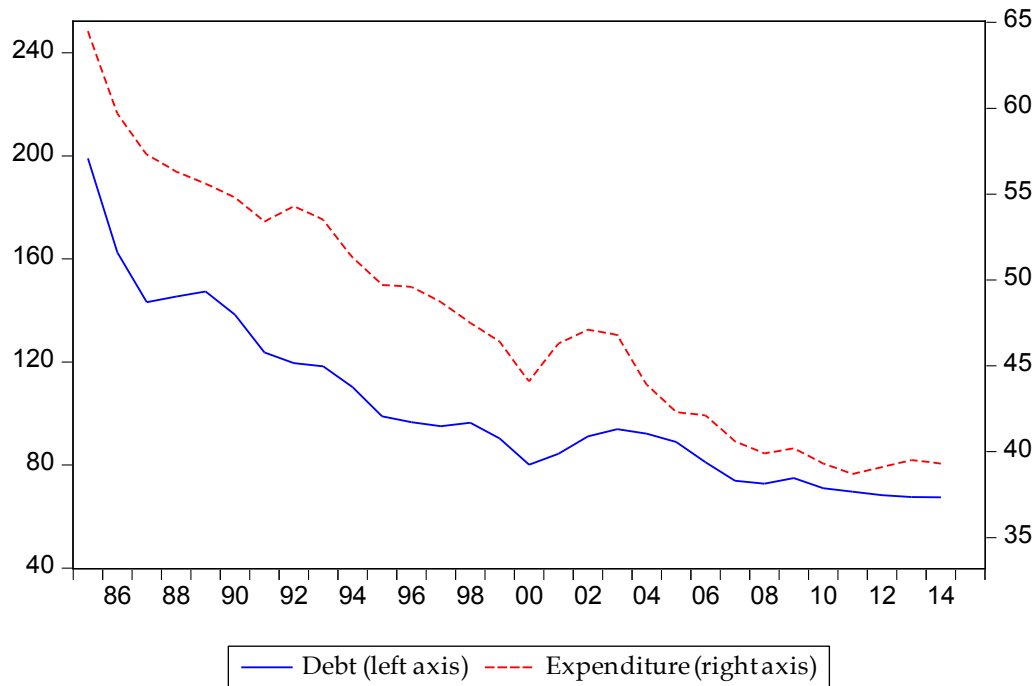
The behavior of expected and actual inflation is further explored using a number of endogenous structural break tests (see Perron, 2006) in a univariate analyses of inflation and expected inflation and find that the series are co-breaking. The inflation steps discussed in Liviatan and Melnick (1999) are also found in expected inflation.

The statistical results are found to be in line with the historical developments in Israel and are related to the conduct of monetary policy, distinct exogenous shocks and the introduction of inflation targeting.

The success of the 1985 stabilization program in Israel clearly illustrates that the elimination of inflation was not achieved through a single act. Even when the fundamental fiscal and monetary policies were adequate, and other heterodox components were used, the disinflation process was long and a long-term commitment to disinflation was required. A high degree of perseverance by both the government and the Central Bank was needed to finally achieve price stability. A key factor in the stabilization process was the government's determination to reduce the public debt and government expenditures, creating a basic economic predisposition for disinflation (see Figure 10).²³

²³ This had also a positive effect on the balance of payments.

**Figure 10. Public Debt and Public Expenditure 1985 - 2015
(percent of GDP)**



Credibility was achieved gradually. First, by stabilizing the inflation rate after its initial drop following the implementation of the stabilization program. This generated the first 20% inflation step. Then, working opportunisticly to stabilize the rate of inflation at a lower rate following the labor supply shock caused by the massive immigration wave. This generated the second 10% inflation step. Although we do not have a formal proof, our conjecture is that this part of Israeli disinflation supports the conclusion of Aksoy et al. (2006, p. 1879): *"We show that the opportunistic wait and see approach to disinflation that relies on favorable exogenous circumstances effectively achieves disinflation over time at a lower cost in terms of output losses than the conventional approach."*

Disinflation continued by adopting an inflation targeting regime, and by gradually abandoning the exchange rate as the nominal anchor of the system. From 1996Q1, after active disinflation monetary policy is applied in the context of

an inflation targeting regime, we observe a gradual reduction of expected inflation. Monetary policy was hampered by a conflict between setting an interest rate consistent with the inflation target and the location and slope of the exchange rate band. After widening the exchange rate band in 1998, the inflation targeting regime gained credibility and expected inflation continued to decline.

The inflation targeting regime was challenged and put to tests by two strong price shocks in 1998Q4 and in 2002Q2. A firm determination shown by the Bank of Israel to deal with those shocks became visible. Monetary policy was highly restrictive with exceptionally high real interest rates (especially in 2002), even when the economy was suffering from a deep recession. This seems to have finally persuaded the public that the Bank was determined to achieve price stability engendering a strong dampening effect on inflationary expectations. The process was finalized by moving to the third and current price stability step.

We conclude that the use of a forward looking inflation targeting regime with an independent Central Bank that is free to use monetary instruments to stabilize the inflation rate was crucial to the elimination of the last 10% inflation step and thus to achieve long-run price stability.

Appendix 1. The Data

The rate of inflation is the annualized percentage change between the average monthly CPI of the quarter from its previous quarter.

Beginning in January 1994, the Bank of Israel began to publish a monthly estimate of its one year horizon expected inflation.²⁴ Expected inflation is estimated by the breakeven between the one year return on a nominal bond issued by the Bank of Israel as an instrument of monetary policy (Makam) and the one year horizon return on a fully indexed to the CPI bond issue by the government (Galil).

The Bank of Israel provided us with unpublished estimates of expected inflation computed using similar methodology, for the period January 1988 - December 1993.²⁵

Expected inflation for January 1986 - December 1987 was constructed in the following way: For the period January 1988 - December 1991 we computed the breakeven between the Makam,²⁶ and the one year horizon fully linked to the CPI Galil.²⁷ Comparing that breakeven estimate with the expected inflation obtained from the Bank, we estimated a 300 basis points average difference. This difference is attributed to a liquidity premium caused by a treasury imposed limit on the issue of Makam by the Bank of Israel.²⁸ We obtained expected inflation for January 1986 - December 1987 by assuming the same 300 basis points liquidity premium added it to the breakeven between the Makam,²⁹ and the one year horizon fully linked,

²⁴ The date is related to the announcement of an inflation target.

²⁵ We would like to thank David Elkayam from the Bank of Israel, for supplying the expected inflation series for that period.

²⁶ Those were taken from the Annual Reports of the Bank of Israel.

²⁷ Those were taken from the data bank of the Bank of Israel.

²⁸ The treasury imposed a ceiling on the amount of Makam that could be issued by the Bank. The ceiling was eliminated in January 2002.

²⁹ See footnote 26.

Galil.³⁰ The quarterly one year horizon expected inflation is the average of the monthly expected inflation in the quarter.

The unemployment series is the quarterly rate of unemployment estimated by the labor survey carried out by the CBS.

The YGAP is the deviation from the quarterly log of GDP published by the CBS.

All data are available on request.

³⁰ See footnote 27.

Appendix 2. Israel's 1985 Stabilization Program

The stabilization program in Israel was one of the first heterodox type programs developed in the 1980s to deal with inflation not only in Israel, but also in Latin America (cf. Bruno et al., 1988). The orthodox component of the program included traditional fiscal and monetary contractionary policies. On the fiscal side, the main component was cutting government spending (primarily defense spending and subsidies), which reduced the government deficit to a sustainable long-run level.³¹ On the monetary policy side, restraint primary credit ceilings were also introduced, resulting in exceptionally high interest rates. Crucial legislation banning the government from borrowing from the Central Bank was also enacted. The law gave the Central Bank the necessary *de facto* independence to carry out independent monetary policy.³² A symbolic measure of the stabilization was to erase 3 zeros from the currency, effectively creating a new currency, the New Israeli Shekel.

It was believed at that time, however, that to stop inflation rapidly and to cut the strong dynamic inertial forces, a non-orthodox component had to be included in the program. A central ingredient of the program was the introduction of a fixed exchange rate vis-à-vis a basket of currencies after a large devaluation at the beginning of the program. The exchange rate was designed to be the nominal anchor of the system. When the program began, an exchange rate shock was amplified by the elimination of subsidies³³ before the imposition of price controls. To avoid wage compensation for the initial price shock, a wage agreement was reached that temporarily stopped the cost of living allowance and provided for

³¹ In the pre-stabilization era the fiscal deficit and thus the trend growth in the public debt were unsustainable in the long-run, as defined in Drazen and Helpman (1990).

³² In the pre-stabilization era money financing was freely used by the government.

³³ In the month of July 1985, when the program started, the CPI rose by more than 37%.

restoring real wages to the pre-stabilization level only after a lag of 6 month.

In order to enhance the credibility of the stabilization program, two further components involving the US government were added. The first component was a one-time grant of \$ 1.5 billion which was designated to serve as a cushion for a possible deterioration of the balance of payments.³⁴ The second, a change in the form of US economic aid to Israel from lending to a grant of \$ 3 billion per year to finance Israel's purchase of military equipment.³⁵ Israel was allowed to convert a small component of this second grant for domestic uses. Finally, the U.S. – Israel Joint Economic Development Group (JEDG), a joint committee of US and Israeli government officials and economists, was assigned the task to track the progress of the program.

³⁴ This was a key component since in the pre-stabilization era the acceleration of inflation was related to balance of payments crises, see Bruno and Fischer (1986), Liviatan and Piterman (1986).

³⁵ The borrowing from the US, before 1985, increased the external debt of Israel and aggravated the unsustainable rise in the public debt.

Appendix 3: Structural Break Point Tests

The testing theory for multiple endogenous breaks was developed by Bai (1997), Bai and Perron (1998), Bai and Perron (2003a), Bai and Perron (2003b). For the sake of robustness, we consider several variants of multiple break tests. Each variant builds on the sum of squared residuals from a regression model, in our case:

$$p_t = \hat{c}_i + \varepsilon_t, \quad i = 1, \dots, l + 1 \quad (\text{A3.1})$$

$$\sum_{i=1}^{l+1} \sum_{t=T_{i-1}+1}^{T_i} (p_t - \hat{c}_i)^2 \quad (\text{A3.2})$$

($T_0 = 0$ and $T_{l+1} = T$) and is based on the corresponding F-statistic

$$F(T_1, \dots, T_l) = \frac{1}{T} \left(\frac{T-(l+1)}{l} \right) \hat{c}' R' (R \hat{V}(\hat{c}) R')^{-1} R \hat{c} \quad (\text{A3.3})$$

where $V(\hat{c})$ is a heteroskedasticity and autocorrelation consistent estimator of the variance of the breaking regression coefficient. The error term ε_t is allowed to follow a different distribution in each of the $l + 1$ steps, implying that the estimator $V(\hat{c})$ varies across the disinflation steps. R is defined such that $R\hat{c} = (\hat{c}'_1 - \hat{c}'_2, \dots, \hat{c}'_l - \hat{c}'_{l+1})$. Apparently, the F-statistic increases and an additional break date becomes more likely, if differences between estimated coefficients of adjacent regimes are large. Bai and Perron (2003b) provide simulated critical values for the following variants of the tests.

In the first step of the *sequential* test, the F-statistic is used to test for a single break over the full sample. The natural breakpoint candidate is the date when the sum of squared residuals is most reduced. Provided that the break is found to be significant, the procedure is repeated for both subsamples to identify a possible second break date. The sequential testing procedure stops when the null of no break cannot be rejected anymore. In the *global* test, optimization is performed along both dimensions, the number of breakpoints and the break dates. Bai and Perron (2003a) propose an efficient algorithm to reduce the computational burden

of the global test considerably. Finally, we use the *combined* break test proposed by Bai and Perron (1998). In this variant, l is determined globally and sequential tests for additional breaks are conducted in each of the $l + 1$ regimes.

In our empirical application, we allow for up to 5 structural breaks implying up to 6 different disinflation steps. Note that this choice covers the case of 3 steps, referring to periods of high, medium and low inflation. We trim 7.5% of the observations at the boundaries of each disinflation step.

The multiple break point test results are summarized in Table A3.1. The columns include the number of breaks l under the alternative hypothesis, followed by the robust test statistic, the relevant critical value and the estimated break dates.

The tests provide a clear picture of the disinflation steps. The global tests exhibit their maximum at $l + 2$ where they both clearly reject the null of a single break. In line with the global tests, the sequential and combined tests also reject the null of a single break. Besides, they show that – even at the 10% level – 2 breaks are not rejected in favor of 3. All tests consistently find the breaks at 1991Q4 and 1999Q1.

Table A3.1 Inflation Steps in Israel: Results from Endogenous Break: 1986Q1 – 2013Q4											
Expected Inflation											
Multiple break test variant	breaks (l) under H_1	test statistic	5% crit. value	first break date	breaks (l) under H_1	test statistic	5% crit. value	second break date	breaks (l) under H_1	test statistic	10% crit. value
global (UD_{max})	1	333.17	8.88	1992Q1	2	513.86	8.88	1998Q2	3	361.03	7.46
global (WD_{max})	1	333.17	9.91	1992Q1	2	610.65	9.91	1998Q2	3	519.75	8.20
Sequential	1	333.17	8.58	1992Q1	2	170.92	10.13	1998Q2	3	2.69	9.41
Combined	1	333.17	8.58	1992Q1	2	170.92	10.13	1998Q2	3	5.47	9.41
Actual Inflation											
global (UD_{max})	1	76.68	8.88	1991Q4	2	106.65	8.88	1999Q1	3	72.50	7.46
global (WD_{max})	1	76.68	9.91	1991Q4	2	126.74	9.91	1999Q1	3	104.37	8.20
Sequential	1	76.68	8.58	1991Q4	2	29.90	10.13	1999Q1	3	5.09	9.41
Combined	1	76.68	8.58	1991Q4	2	29.90	10.13	1999Q1	3	2.75	9.41

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